



2021 Annual Report Long Term Ash Management Strategy (LTAMS) – Progress of reuse and recycling of ash

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Please see document control section for more information.

Contents

Contents	2
Executive Summary	3
1 Introduction	5
2 Ash Reuse Statistics and Program	6
2.1 FY21 Ash Reuse Statistics	6
2.2 Ash Reuse Program	6
2.2.1 Contracted Volumes	6
2.2.2 Expected Volumes (FY22)	6
2.2.3 Potential Volumes	7
2.3 Barriers to Ash Reuse	8
2.4 Options for Minimisation of Ash Disposal	9
2.5 Forecast Ash Production	9
2.6 Forecast Ash Reuse	10
3 Framework for the Identification and Assessment of Alternative Ash Management Options	11
3.1 Overview	11
3.2 Identification and Assessment Framework	11
4 Monitoring and Auditing Program	12

Executive Summary

Origin Energy Eraring (Origin) operates the Eraring Power Station (EPS) as part of its electricity generation portfolio which provides electricity into the National Electricity Market. The EPS is a coal fired power station consisting of four 720 megawatt (MW) units and one 42MW diesel fuelled gas turbine with a total capacity of 2,922MW. Ash produced by the EPS which is not re-used, is stored on site in the Eraring Ash Dam (ERAD).

The Long-Term Ash Management Strategy (LTAMS) summarises the commitment by Origin to improve the efficiency of, and reduce environmental impacts associated with, the operation of the EPS and the ERAD. The LTAMS is reviewed and updated on an annual basis with the aim of minimising the ash sent to our long-term storage and maximising the amount of ash that is reused and recycled.

This Annual report provides a summary of the progress of reuse and recycling of ash for the period 1 July 2020 to 30 June 2021. This year's report (2021) also provides a summary of 1 July 2021 to 30 September 2021 ash recycling as the initiatives that have been developed in FY21 have had a significant impact on increasing our ash reuse recycling rates.

Origin remains committed to minimising the quantity of coal ash that is sent to the ERAD consistent with the NSW Department of Planning, Industry and Environment's (DPIE) ash reuse goal of 80% by 31 December 2021. Origin achieved this goal in September 2021 with a monthly ash reuse rate of 96%. The ash recycling rate in Q1 FY22 was 77% more than doubling the FY21 rate of 36%. Achievement of this goal was made possible by a very diligent and consistent effort to increase EPS ash recycling as outlined in this LTAMS.

Being able to maintain such a high rate of recycling will require ongoing regulatory enhancement and support, and the establishment of new markets given the cap on ash demand in traditional markets. Origin is pleased with the findings of the NSW Legislative Council Report 4 - March 2021 Public Works Committee - Costs for remediation of sites containing coal ash repositories as they relate to ash reuse and we look forward to engaging with government on achieving successful outcomes with regards to the reports recommendations.

In FY21, Origin recycled ~36% of all EPS ash produced, which is a decrease on FY20 reuse rates. Origin remains the largest recycler of ash in NSW. Absolute recycled volumes also declined against FY20 primarily due to the delayed impacts of COVID restriction on ash sales and lower bottom ash sales.

Origin has the potential to reach and maintain sustainable high ash reuse rates, however this is partially dependent on the removal of regulatory barriers which currently limit the ash market's expansion.

These regulatory limitations include:

- 1) Misalignment of coal ash quality standards between the Australian Standards and the Roads and Maritime Services (RMS) standards.
- 2) Limitations set by RMS standards governing the maximum amount of coal ash used in roads.
- 3) Uncertainty regarding application of resource recovery legislation to coal ash reuse.

In addition to the barriers above, there are also limitations on the demand for EPS ash through traditional markets such as an ingredient in cement and concrete, and as a stabilisation material in land remediation – this effectively creates a cap on the volume of ash EPS can re-use in the absence of regulatory support or establishment of new end use markets.

While Origin continues to seek regulatory support in the areas identified above, it is also investing capital in infrastructure and research & development activities (R&D) in order to expand traditional markets or create new markets for EPS ash. Origin has recently co-invested in an on-site classifier to further refine run of station ash to a quality suitable for the construction industry and is undertaking R&D activities to

develop a low cost, light weight aggregate material. Further, despite the limitations of ash use in roads currently imposed by the RMS, Origin is undertaking further investigations to validate the use of high quantities of ash in roads.

Origin is also actively participating in and advocating for collaboration between generators, government agencies, regulators and potential customers to achieve optimum recovery of ash as a resource.

1 Introduction

Origin's Long-Term Ash Management Strategy (LTAMS) for Eraring Power Station (EPS) represents a commitment by Origin to improve the efficiency of, and reduce environmental impacts associated with, the operation of the EPS and the Eraring Ash Dam (ERAD). The LTAMS is a tool for both Origin and Government agencies to guide significant reductions in ash storage at EPS through an increase in reuse and development of new technologies in ash management. The LTAMS is used as a management tool to allow for progress in these areas to be measured and monitored on a regular basis and reported back to the relevant stakeholders.

This report provides the 2021 update of annual progress of reuse and recycling of ash, as required by Condition 4A.2 of Project Approval PA07_0084 MOD1. Condition 4A.2 is as follows:

4A LONG-TERM ASH MANAGEMENT STRATEGY

4A.2 By the end of October each year, or other timeframe agreed by the Planning Secretary, a report shall be submitted to the Department to demonstrate annual progress of reuse and recycling of ash, to the satisfaction of the Planning Secretary.

This report includes the following important information relevant to demonstrating compliance with Condition 4A.2:

- **Section 2** Ash Reuse Statistics and Program – outlines ash reuse volumes and rates compared with previous years and well as a comparison with the 80% ash recycling goal. It also includes forecast ash reuse and planned projects and initiatives being progressed to enable ongoing ash recycling at high rates.
- **Section 3** Framework for the Identification and Assessment of Alternative Ash Management Options – provides the overarching approach to ash recycling opportunity identification and assessment.
- **Section 4** Monitoring and Auditing Program – provides an overview of the various LTAMS reviews and reporting that are completed at regular intervals.

2 Ash Reuse Statistics and Program

2.1 FY21 Ash Reuse Statistics

In FY21, Origin's ash reuse rate decreased from 40% to 36%. Origin remains the largest recycler of ash in NSW. Absolute recycled volumes also declined against FY20 primarily due to the delayed impacts of COVID restriction on ash sales and lower bottom ash sales. The impact of COVID was to reduce construction activity and by direct correlation the amount of ash that was recycled in FY21. In FY21 our primary ash recycling purpose was for use in construction materials.

Actual ash reuse data is provided in Table 1.

Table 1 Rates of Reuse for ash Produced at EPS

Year	Reuse Amounts (tonnes)	Reuse Rates
FY16	505,622	36.6%
FY17	361,839	27.6%
FY18	477,292	29.8%
FY19	602,580	34.8%
FY20	559,710	39.3%
FY21	485,287	35.7%

2.2 Ash Reuse Program

Origin has a three-tiered reuse program in place designed to decrease the quantity of ash required to be impounded in the Earing Ash Dam, with a long-term view to harvesting ash from the Dam to continue supply to markets which aims to maintain high rates of ash recycling.

1. Contracted Volumes
2. Expected Volumes
3. Potential Volumes

2.2.1 Contracted Volumes

Origin's ash reuse program has three key contracted customers, primarily in the cement and concrete industry, who are responsible for 481kt, or 99%, of the FY21 sales. This market is well established, demand is capped and driven by swings in the construction industry and broader economic drivers. Origin expects these sales to be on-going for the remainder of EPS's life and intends to increase supply to these customers by undertaking a program to increase the efficiency of the Coal Combustion Products Plant (CCP Optimisation) to enhance our ability to supply ash to this just-in-time industry.

2.2.2 Expected Volumes (FY22)

Through the implementation of the existing and future ash use initiatives and the innovative new products and technology opportunities, Origin has worked hard towards achieving the ash reuse goal of 80% by December 2021, successfully meeting and exceeding the goal in September 2021 with a monthly ash recycling rate of 96%.

Origin has two large projects underway to increase the ash reuse rate which commenced operation in 2021.

The first is a partnership with a local ash supply firm to install a large capacity classifier to increase the supply of RMS grade ash to market. This initiative is intended to increase sales by ~200kt over three

years, a significant step change in Origin's reuse rate. The increase in sales is reliant on a current Project Approval Modification (PA07_0084 MOD2) being approved.

In terms of the second project in July 2021 Origin commenced a supply deal to a local mine rehabilitation project which is expected to utilise ~1Mt+ of ash. This project will be completed over approximately two years. Importantly this project has seen a significant increase in ash reuse in recent months with the percentage reuse increasing as follows:

- July 2021 - 62%
- August 2021 - 75%
- September 2021 - 96%

On a monthly basis Origin achieved and exceeded the 80% ash reuse goal required by condition 4A.1a ahead of the December 2021 timeframe and importantly the ash recycling rate in Q1 FY22 was 77%, more than doubling the FY21 rate of 36%.

2.2.3 Potential Volumes

Origin is exploring a wide range of potential reuse applications, including, but not limited to, increasing contracted volumes (mine void remediation, lightweight aggregate, bricks and blocks and fly ash pavements / roads). The extent to which these markets can be pursued, and current sales channels uplifted, are dependent on two key factors; market dynamics and the regulatory environment. A summary of the opportunities investigated are as follows:

1) Additional EPS ash storage (silos)

Origin is in the process of finalising a development approval modification (PA07_0084 MOD2) for up to 7 additional ash storage silos on-site with a total storage capacity of up to 3,750 tonnes.

This is an important initiative for sustaining high rates of ash recycling given the fluctuating market conditions for ash supplied to the concrete construction industry. High storage volumes enable ash to be supplied continuously at high rates when there is high market demand for ash. When the market is low, more ash can be stored in silos, reducing ash volumes being sent to the ERAD.

2) Ultra-high-volume fly ash pavement/roads

Origin has conducted a detailed durability assessment of an ultra-high-volume fly ash pavement constructed on the Coal Haul Road at EPS in 1995. Results of testing undertaken in 2018 indicate that the road has outperformed the standard heavy vehicle pavement design. Origin is seeking to develop the product offering further and is working with Transport for NSW and the local Lake Macquarie City Council (LMCC) to develop this initiative further.

Ultra-high-volume fly ash pavements are not yet feasible in NSW due to regulatory limitations. Meaningful implementation of this opportunity requires engagement with the RMS and local council stakeholders to trial the product and enable the commercial roll out via a change of the relevant RMS Standards for pavements.

3) Mine void rehabilitation and structural fills

As stated above, Origin have commenced a large scale ~1Mt+ ash supply project for mine rehabilitation. This is a 3-year project from 2021.

We continue to investigate the opportunity for additional projects including for mine void grouting as contracted sales / supply.

4) Lightweight aggregate manufacturing

Origin is undertaking a research and development project with a local construction firm to develop a lightweight aggregate using ash from the ERAD. The goal of the R&D program is to determine viability of developing a commercial scale manufacturing process to produce a range of coarse and fine aggregates for use in concrete and other traditional aggregate applications.

5) Pre-cast building materials

Origin is in various stages of research and negotiation with numerous organisations for the construction and operation of various building material manufacturing plants at EPS that would bind coal ash to produce a range of pre-cast building materials including blocks, bricks, pavers and tiles.

6) Cenospheres

Origin is investigating the recovery and supply of cenospheres to a number of potential customers. However, this has been delayed by the recent uncertainty regarding whether the Coal Ash Order and Exemption applies to this material, as cenospheres are sourced from the ERAD. The supply of cenospheres would be a success for the reuse program but more importantly the ash management strategy, as cenospheres are a significant contributor to dusting events.

7) Proppants

Origin has reviewed the opportunity to use fly ash as a proppant in CSG exploration and production. However, the volumes are small (~15ktpa) and is not economically viable.

8) Ash amended road base pavements and quarry products

Origin has undertaken a range of product development trials with a regional quarry to incorporate ash products into sub grade, road base and other quarry materials suitable for utilisation in the Lake Macquarie City region. Origin intends to expand these applications within the local area, however, we face strong competition from the well-established natural aggregates market. There has been increased interest in the use of ash as an additive to quarry materials. Origin will continue to investigate options with local quarries and civil project developers.

9) Agriculture

Origin is not investigating options for ash as soil ameliorant as the resource recovery legislation imposes a frequent testing regime that is not currently practicable given the small market demand for ash as a soil ameliorant.

2.3 Barriers to Ash Reuse

The construction industry is the largest driver of demand for fly ash, therefore Origin's success in ash reuse is largely defined by the performance of NSW's construction industry and the broader economy as a whole. Origin achieved an ash reuse rate of ~36% in FY21, a decrease from the FY20 rate of 39%. This was the result of difficult economic and operating conditions created by the COVID-19 pandemic. Outside of the significant recent uplift in recycling attributed to mine rehabilitation project these poorer economic conditions have impacted Origin's forecasted ash reuse rates by delaying the start of ash reuse initiatives and impacting future demand for fly ash.

Additionally, the current regulatory environment limits Origin's ability to increase ash reuse. As part of our submission to the NSW Legislative Council's inquiry into the costs for remediation of sites containing coal ash repositories, Origin outlined three key areas where the current regulatory environment does not support the remediation of coal ash repositories:

1) Misalignment of standards between the Australian Standards and the RMS.

The current RMS standards require a higher quality for fly ash than the national standards. Aligning the RMS standards with the Australian standard will facilitate the substantial increase of re-use of coal ash in concrete applications.

2) Regulation governing the maximum amount of coal ash used in roads.

A change to the regulations that limit fly ash in road applications to a performance-based standard would allow a substantial increase in the use of fly ash in pavements and other quarry products. Origin has successfully implemented an ultra-high fly ash pavement on its private haul

road which contains 92% ash which has exceeded performance standards over a 25-year test period.

- 3) Uncertainty regarding application of resource recovery legislation to coal ash reuse.** Ash recycling projects have also been delayed as a result of uncertainties with regard to the interpretation of resource recovery legislation and the need to assess projects on a case-by-case basis. Origin continues to work with NSW EPA to identify ways in which ash projects can be progressed in an environmentally safe and timely manner.

Origin welcomed the NSW Legislative Council Report 4 - March 2021 Public Works Committee - Costs for remediation of sites containing coal ash repositories (the Report).

In this report the Chair, The Honourable Daniel Mookhey, MLC states:

The committee found that coal ash is a valuable resource with widespread support across the spectrum of stakeholders for its greater reuse. This will lead to industry development and job creation, a reduction in environmental harm and contribute to developing a circular economy. Therefore, the committee has made recommendations that promote circular economy principles when dealing with coal ash waste and reuse, and support feasibility studies and pilot projects to assess and demonstrate commercial viability of new industries that boost the reuse of coal ash.

We share the NSW government's view with regards to ash reuse and see the ash reuse and recycling recommendations made in the Report as positive step forward in reducing regulatory barriers to ash reuse.

2.4 Options for Minimisation of Ash Disposal

In line with the DPIE's intention to reduce the amount of ash impounded on a yearly basis in the ERAD, Origin has options available outside of increasing ash reuse. These options are being investigated and implemented where commercially feasible:

- **Coal Sourcing:** Origin has improved the quality of coal procured for EPS which has seen the average ash content of the collective coal portfolio reduce. These higher grades of coal are priced above high ash coals, and this cost is factored into EPS's short run marginal cost.

Origin estimates it has reduced average annual ash production by ~40ktpa over the last three financial years through procurement of lower ash coal when compared with historical coal types.

- **EPS Generation Management:** Origin has reduced the annual EPS generation levels in FY20 to 13.3TWh, a 3% reduction of the prior year's peak of 13.7TWh. This led to an ~54kt decrease in ash production from previous years.

While the reduced generation levels will not be reflected in the DPIEs 80% reuse goal, the reduction in EPS generation has a material impact on the overall ash produced and in turn, sent to the ERAD.

2.5 Forecast Ash Production

Future ash production is directly related to the energy produced and the quality of coal utilised. If Origin maintains the current the generation rates and coal quality, the annual ash production could be up to ~1.5 million tonnes per annum (Mtpa). That is 16.5 Mt of additional ash over the 11-year period from 2021 to end 2032. An 80 % ash reuse goal equates to approximately 1.2 Mt of ash use per annum, and if the goal was achieved from 2022 then 13.2 Mt of ash would be recycled of the total 16.5 Mt produced through to the end of 2032.

Origin is continuing our efforts to maintain ash recycling at high levels (above 80%) and plan to sustain ash reuse as high as possible out to the end of power station coal operations planned to occur by 2032.

However, ash reuse rates, as a factor of as production, are subject to the generation demands of the National Electricity Market. During periods where generation demand is consistently high, percentage reuse rates may be negatively impacted, despite reuse tonnages remaining comparatively stable or increasing. Conversely, as generation demands reduce due to the impact of renewables, we may see a correlating increase in our recycling rates due to lower production.

2.6 Forecast Ash Reuse

Origin has forecasted a range of ash reuse outcomes, dependent upon the success of the program as subject to the barriers outlined in Section 2.3.

Origin will continue to investigate and implement options that are commercially feasible to maintain a high ash reuse and recycling rate. Our primary driver being to reduce the amount of ash that is sent to our long-term storage facility (ERAD).

The mine rehabilitation project that has commenced in FY22 has been strategically important as it has proven our impounded ash as being a valuable resource for future use. We have commenced investigations into further use of recovered ash from our impoundment and this will require regulatory assistance.

Origin forecasts that we are well placed to continue to reuse and recycle most of our ash (as a percentage of ash produced), subject to the afore mentioned barriers being overcome.

3 Framework for the Identification and Assessment of Alternative Ash Management Options

3.1 Overview

Origin has designed and implemented detailed program for the investigation and development of ash reuse opportunities as alternatives to the storage of ash at the ERAD.

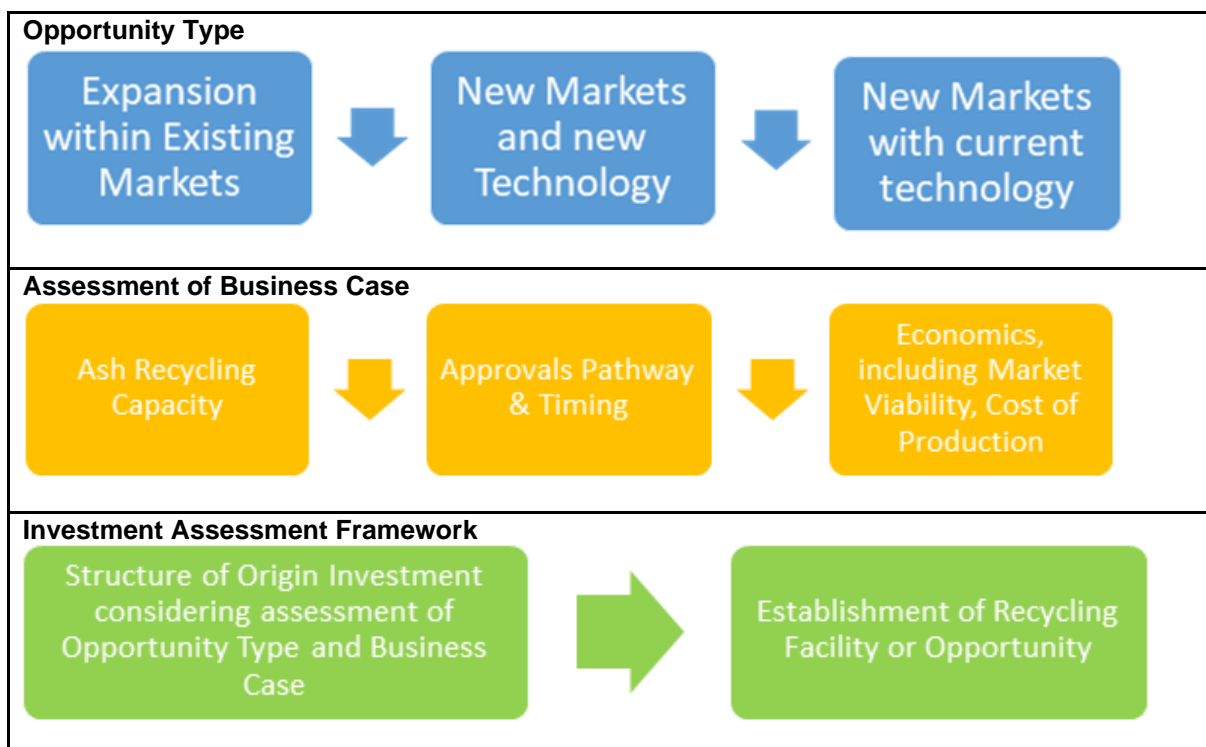
Origin has taken the following steps to further develop the framework, including:

- Active participant in the Ash Development Association Australia (ADAA),
- Engagement with global fly ash industry bodies (UK Quality Coal Ash Association and the American Coal Ash Association etc)
- Regular meetings with key stakeholders within relevant State and Local Government departments to facilitate access to opportunities for ash use in government projects.
- Engagement with local and international industry research bodies to investigate options to increase ash reuse.

3.2 Identification and Assessment Framework

Origin has developed a detailed framework for the identification, investigation and development of alternatives to ash storage at the existing ERAD through possible ash recycling and reuse options.

An overview of the framework is set out below.



4 Monitoring and Auditing Program

Specific aspects of the LTAMS are subject to regular monitoring and auditing. The monitoring and auditing procedures adopted by Origin in this respect are summarised as follows:

- Annual review of condition relating to the 80% reuse goal (noting it was achieved in Sep 2021 and actual reuse rates are subject to market conditions)
- Annual Review, update and endorsement of LTAMS
- Annual reporting of ash reuse and recycling as part of Origin Sustainability Report
- Quarterly review of ash reuse and recycling (Origin Sustainability reporting)
- Quarterly review and tracking of existing markets for reuse of ash
- Ad Hoc 2nd line assurance review of ash recycling, sampling and performance